



Removal of Perchlorate and RDX in Groundwater

National Groundwater Association 2005 Conference on MTBE and Perchlorate

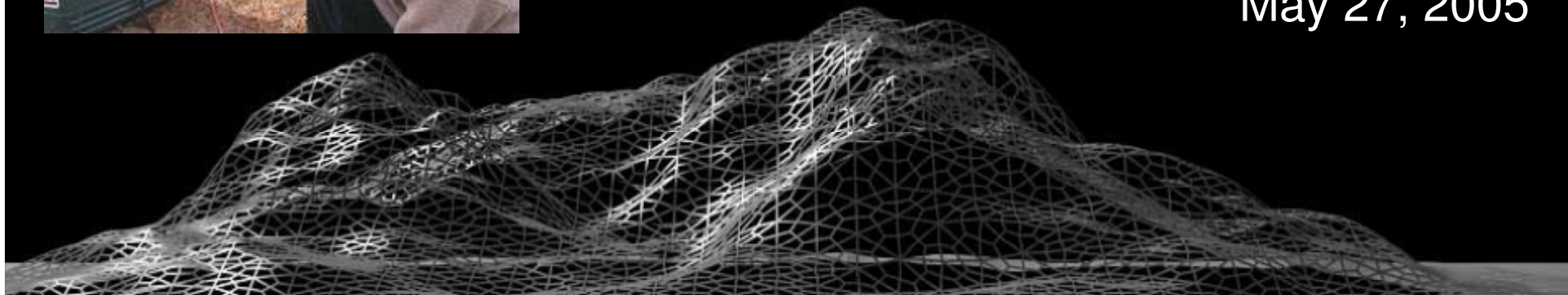


Katherine Weeks, P.E. (AMEC)

Fred Cannon, Ph. D. (PSU)

Ian Osgerby, Ph. D. (USACE)

May 27, 2005

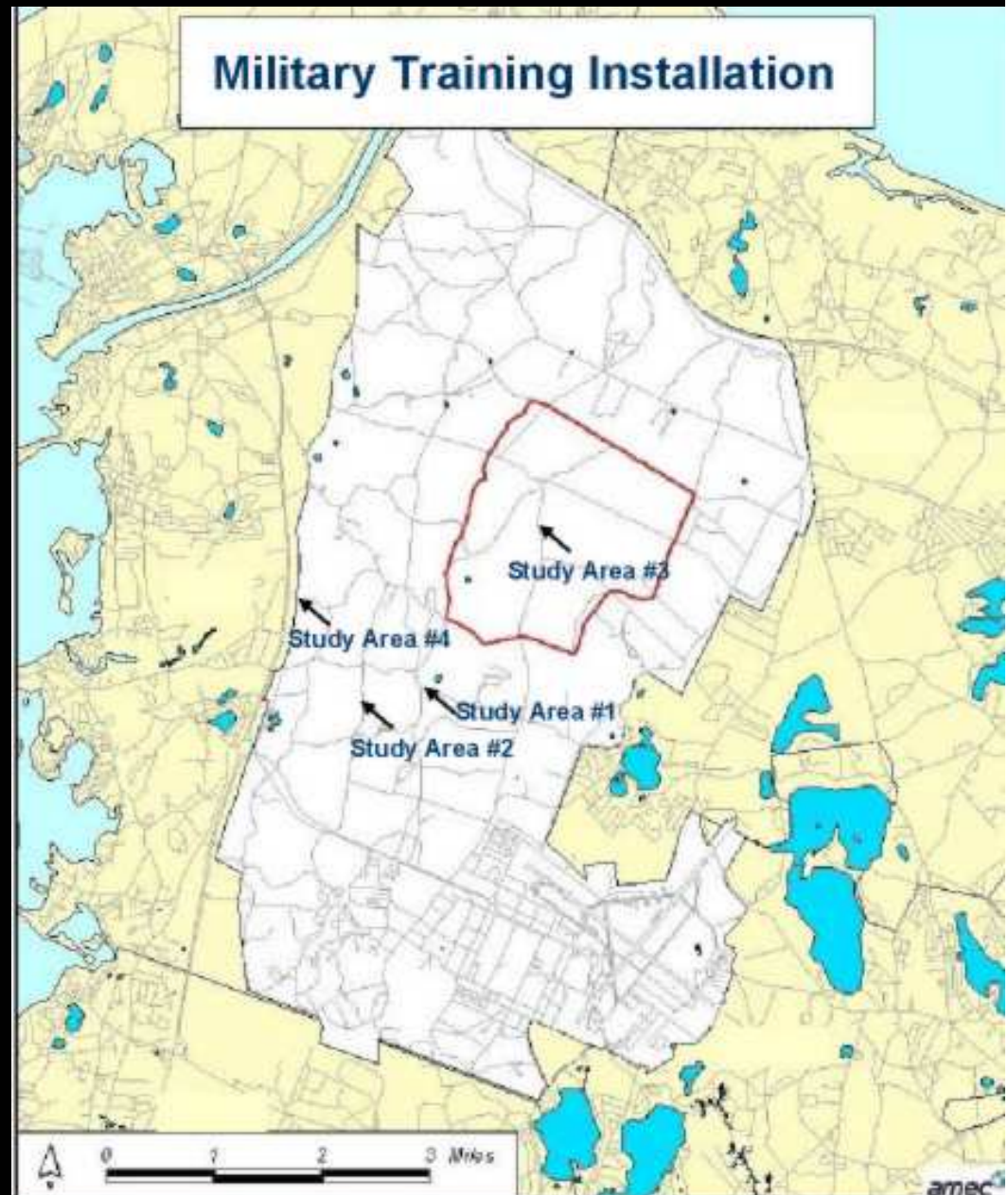


Acknowledgements

- Army National Guard
- Army Environmental Center
- US Filter Corporation
- The Purolite Company
- Ceimic Laboratories
- Severn Trent Laboratories
- Shaw Environmental & Infrastructure, Inc.
- DL Maher (div. of Boart Longyear, Inc.)
- National Environmental Systems

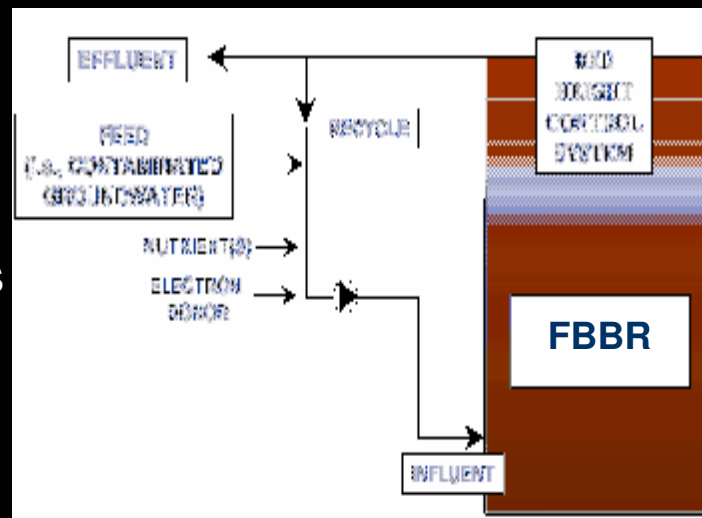
Site History

- History - Impact Area and Ranges at Site used for training since 1911
- Mission - Evaluate innovative remediation technologies to treat low levels of perchlorate and explosives in soil and groundwater



Ex Situ Groundwater Treatment Technology Evaluation

- Fluidized Bed Bioreactor (FBBR)
 - Vessel contains fluidized granular medium
 - Bacteria biologically degrades contaminants
- Ion Exchange Resin (IX Resin)
 - Removes contaminants using anion exchange
- Granular Activated Carbon (Standard GAC)
 - Removes contaminants through sorption
- Tailored GAC
 - Addition of proprietary cationic monomer
 - Acts like ion exchange resins



FBBR Process Flow
Courtesy of Shaw E&I



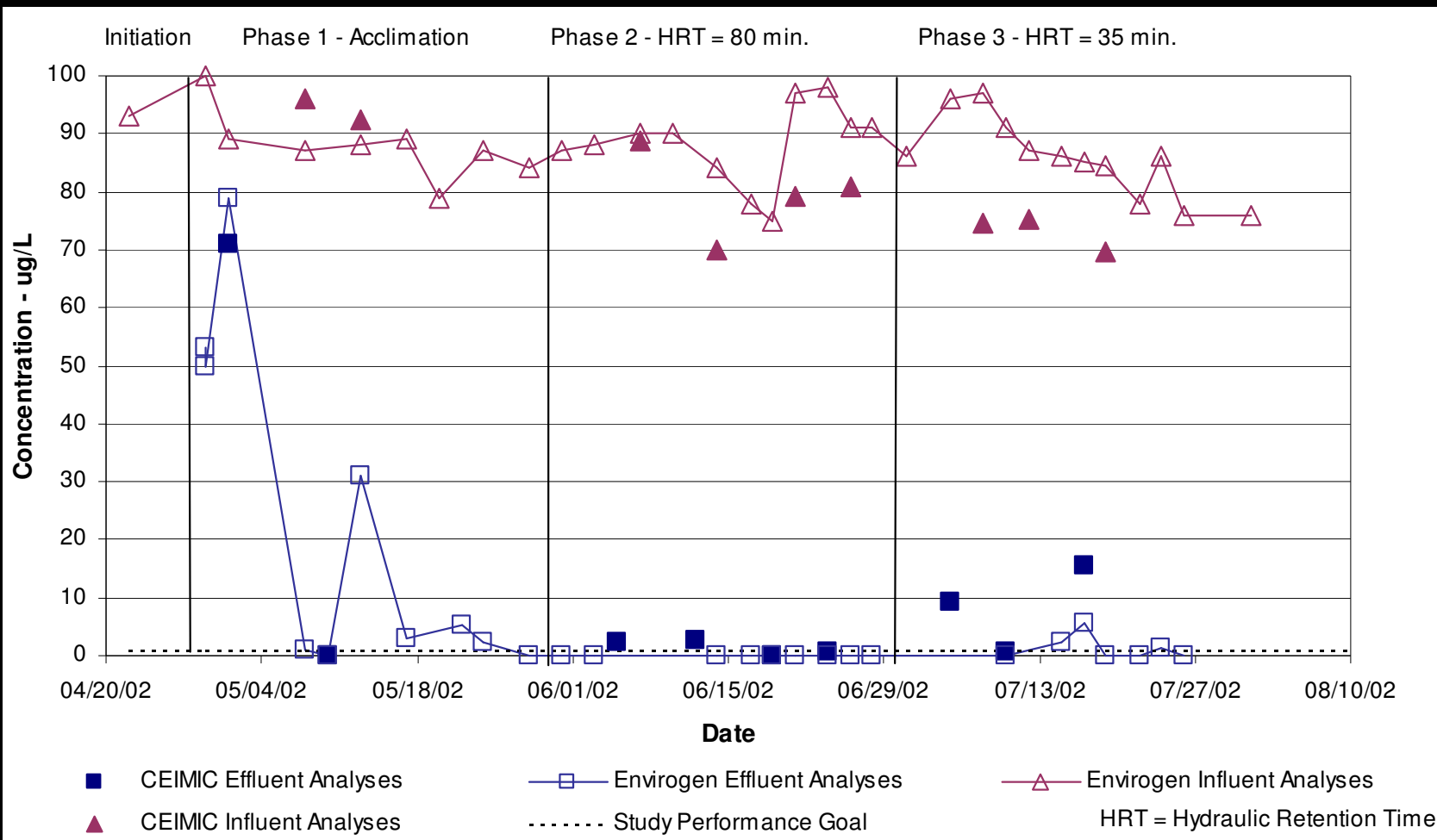
Ion Exchange Resin
Courtesy of The Purolite Company



Site Contaminant and Aquifer Characteristics

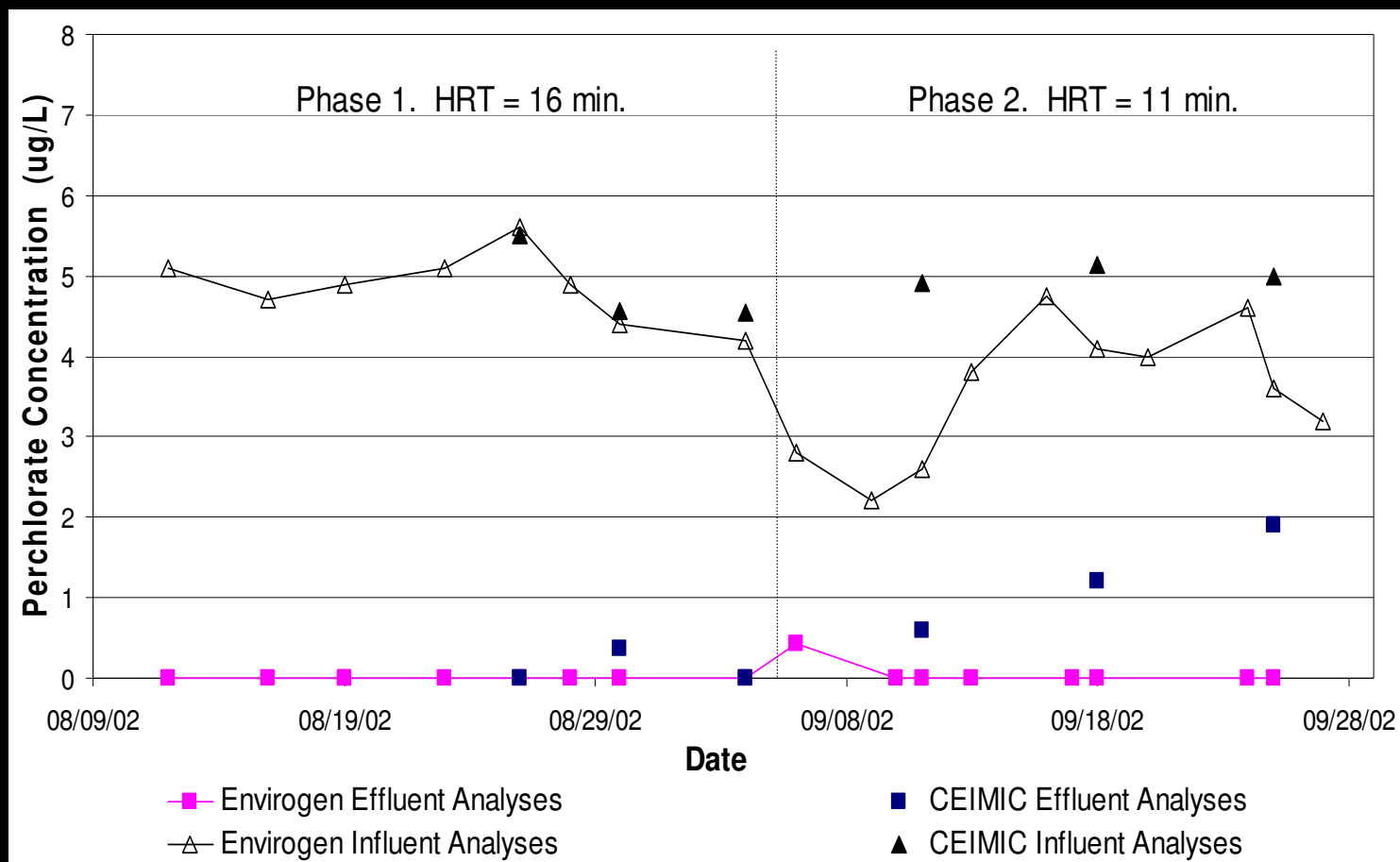
Parameter	Area #1	Area #2	Area #3	Area #4
Perchlorate (µg/L)	100	3 - 5	1	1
RDX & HMX (µg/L)	200	0	6	0
Nitrate (mg/L)	2.2	<0.12	0.05	0.1
Sulfate (mg/L)	4.6	6.1	4.4	5.0
Chloride (mg/L)	7.6	7.9	7.2	8.7
pH (S.U.)	5.8	6.3	5.4	5.7
Dissolved Oxygen (mg/L)	9.8	9.4	10.6	9.2
TOC (mg/L)	<1.0	<1.0	0.59	0.68

FBBR Study Results – Study Area 1



FBBR (Acetic Acid) Effluent Perchlorate vs. Time

FBBR Study Results – Study Area 2



FBBR (Acetic Acid) Effluent Perchlorate vs. Time

Standard GAC RSSCT Results

Test	Test 1	Test 2	Test 3
<u>Source Study Area</u>	<u>#4</u>	<u>#1</u>	<u>#3</u>
Perchlorate ($\mu\text{g/L}$)	1	5	1
RDX & HMX ($\mu\text{g/L}$)	0	0	6
EBCT (min)	20	5	10
BV to Perchlorate BT	30,000	22,000	43,000
BV to RDX BT	N/A	N/A	308,000
<u>Effective Bed Life (mo)</u>	<u>13</u>	<u>3 - 4</u>	<u>9 - 10</u>

EBCT = Empty Bed Contact Time BV = Bed Volumes BT = Breakthrough
 Effective Bed Life = time between media change-outs (months)

Tailored GAC RSSCT Results

Test	Test #4	Test #5
Source Study Area	#2	#3
Perchlorate ($\mu\text{g/L}$)	5	1
RDX & HMX ($\mu\text{g/L}$)	0	6
EBCT (min)	5	9
Tailored GAC BV to Perchlorate BT	170,000	270,000
Tailored GAC BV to RDX BT	N/A	8,000
Straight GAC BV to RDX BT	N/A	308,000
<u>Effective Bed Life (mo)</u>	<u>9 - 19</u>	<u>56</u>

EBCT = Empty Bed Contact Time BV = Bed Volumes BT = Breakthrough
 Effective Bed Life = time between media change-outs (months)
 Bed Life applies only to perchlorate treatment, not RDX treatment



Field Study - Tailored GAC, IX Resins

Media	Tailored GAC	A520E Resin	A600E Resin
Source Study Area	#2	#2	#2
Perchlorate (µg/L)	3	3	3
Explosives (µg/L)	0	0	0
EBCT (min)	5	5	5
Bed Volumes Processed	60,000	60,000	60,000
Predicted Bed Volumes	150,000	72,000	15,000
Predicted Bed Life (months)	> 16	> 8	> 3


A520E = Purolite Nitrate Selective ion exchange resin

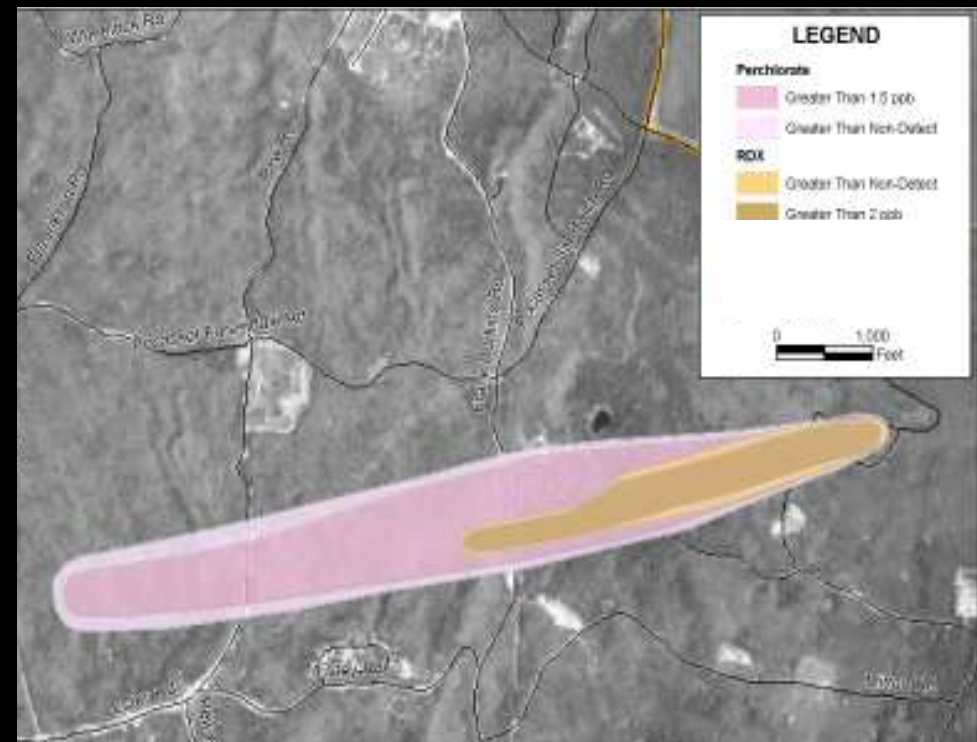
A600E = Purolite Type I Styrenic ion exchange resin

EBCT = Empty Bed Contact Time BV = Bed Volumes

Predicted Bed Life = time between change-outs

Pilot Study Implementation

- First full scale perchlorate remediation system in New England
 - Plume 1,000 feet wide, 10,000 feet long
 - Total 320 gpm treated
 - 5 minute EBCT
 - Perchlorate 3 – 37 ug/L
 - RDX 0 – 5 ug/L
- 
- An aerial photograph showing a river, likely the Merrimack River, with a plume of contaminated water extending from it. The plume is visible as a lighter, more turbid area in the water. The text 'MERRIMACK RIVER' is visible in the upper left corner of the image.

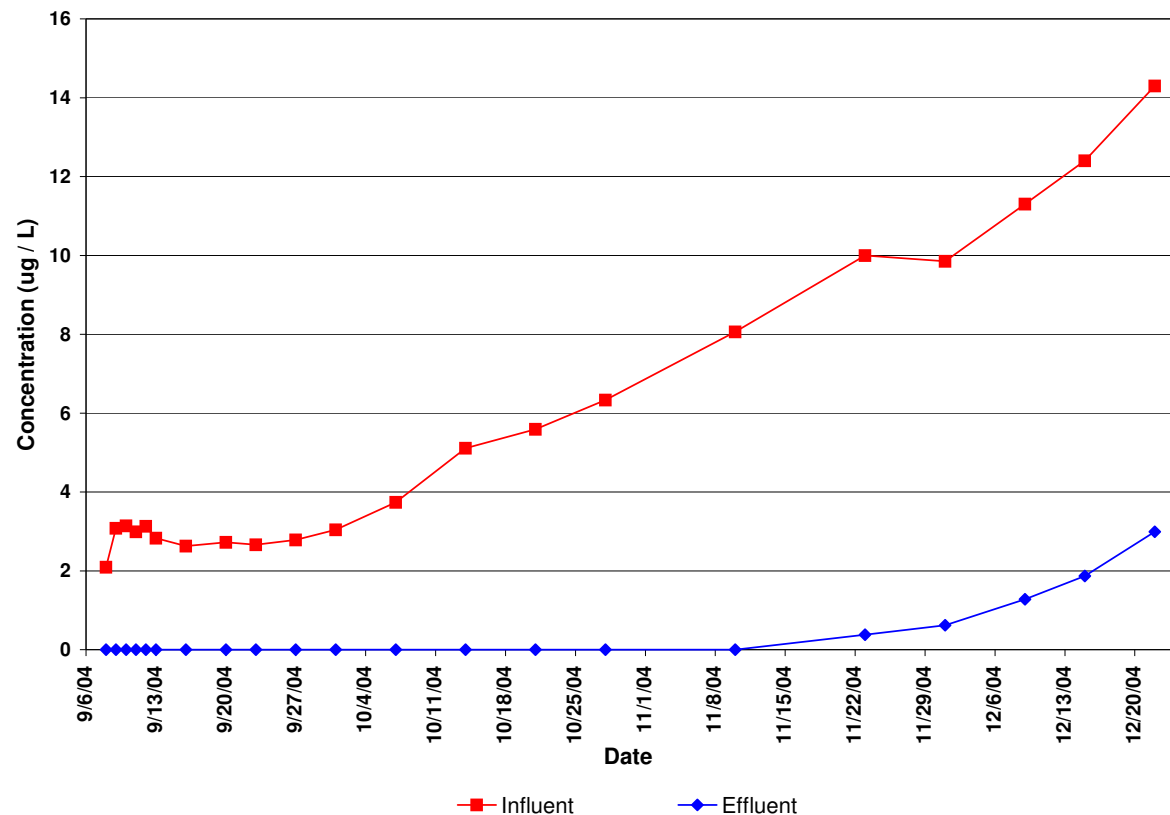


Implementation – System A

- 100 gpm treated
- Perchlorate average 7 ug/L
- Standard GAC
- Breakthrough at 17,000 Bed Volumes

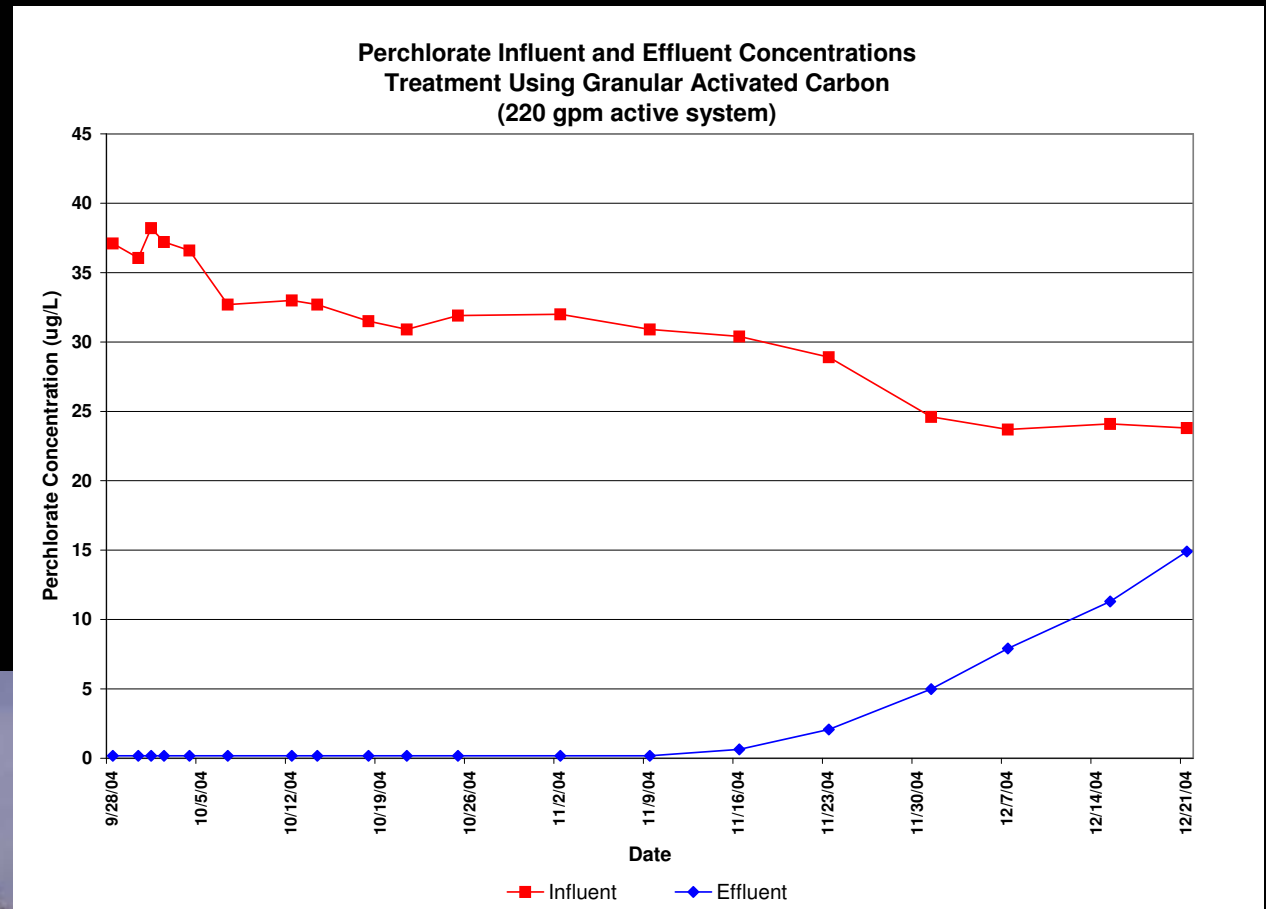


Perchlorate Influent and Effluent Concentrations
Treatment Using Granular Activated Carbon
(100 gpm active system)



Implementation – System B

- 220 gpm treated
- Perchlorate average 33 ug/L
- Standard GAC, IX Resin
- Breakthrough at 9,000 Bed Volumes



Implementation Cost Comparison

Treatment Scenario	Comparative Cost
1 µg/L perchlorate, 6 µg/L explosives	
Standard GAC	1X
Tailored GAC	2.5X
Nitrate Selective IX Resin	4.5X
5 µg/L perchlorate	
Tailored GAC	1.5X
Standard GAC	2x
Nitrate Selective IX Resin	4x

Assumptions:

- Costs are for media only, except for Tailored GAC, where extra analytical costs are added. When Tailored GAC is NSF approved, costs are reduced by 0.5X
- Tailored GAC & IX systems requires extra Standard GAC vessel to treat explosives

Conclusions

- FBBR can be cost effective for perchlorate $> 500 \mu\text{g/L}$
- IX resins still the workhorse for perchlorate $10 - 1000 \mu\text{g/L}$
- Standard GAC is cost effective for perchlorate at $1 - 7 \mu\text{g/L}$
 - May change when Tailored GAC gets NSF approval
 - May change if IX resin costs keep dropping
- Competition will be good for the end users